ATMOSPHERE Observing System

National Aeronautics and Space Administration

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AOS Inclined Time-Varying Observations of Aerosols, Clouds, Convection, and Precipitation

John E. Yorks (NASA GSFC)

Scott Braun (NASA GSFC), Ed Nowottnick (NASA GSFC), Takuji Kaubota (Japan Aerospace Exploration Agency), Hélène Brogniez (LATMOS-IPSL/University of Versailles), Emily D. Berndt (NASA MSFC), Tyler Thorson (NASA LaRC), Daniel Cecil (NASA MSFC)

Pre-Decisional – AOS is in Pre-Phase A and NASA makes no commitments on the final design of the mission or instruments

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Current AOS Architecture (Pending)

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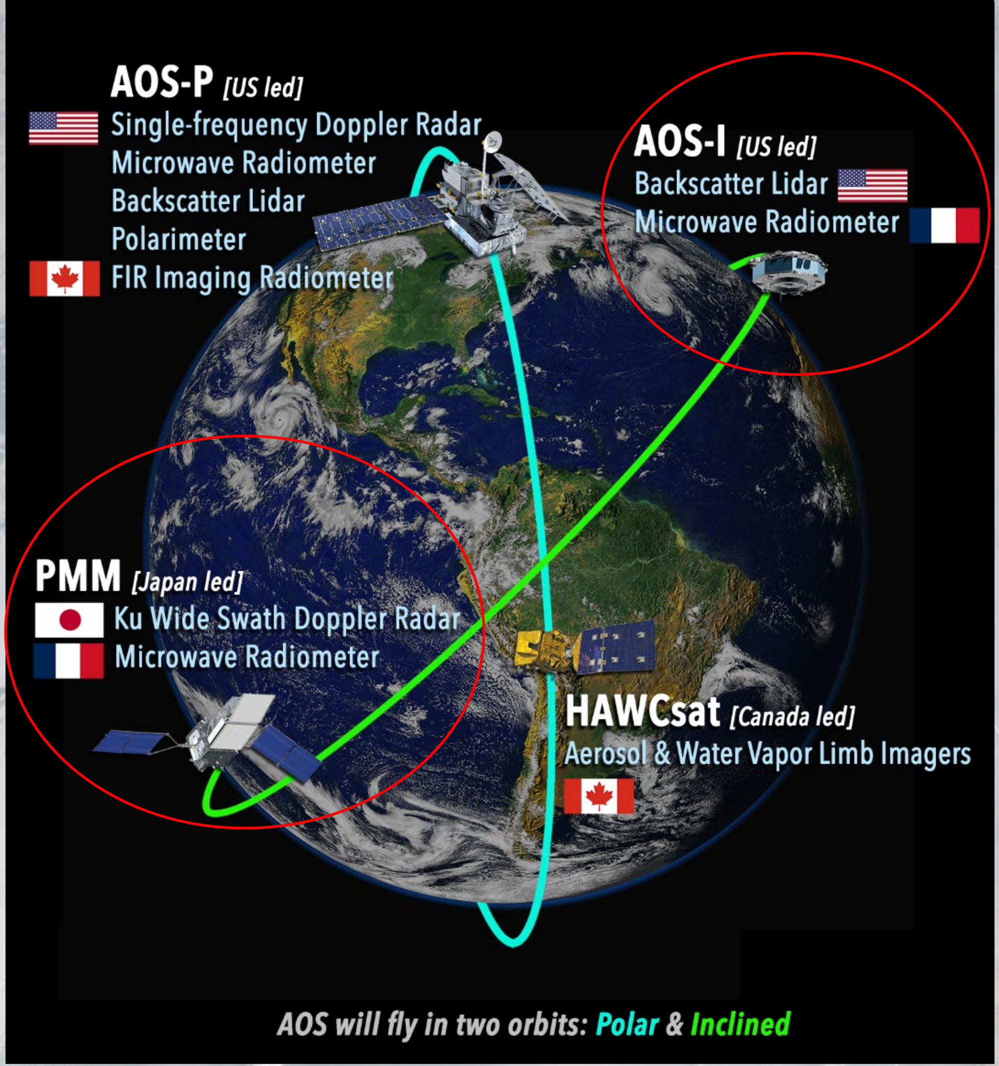
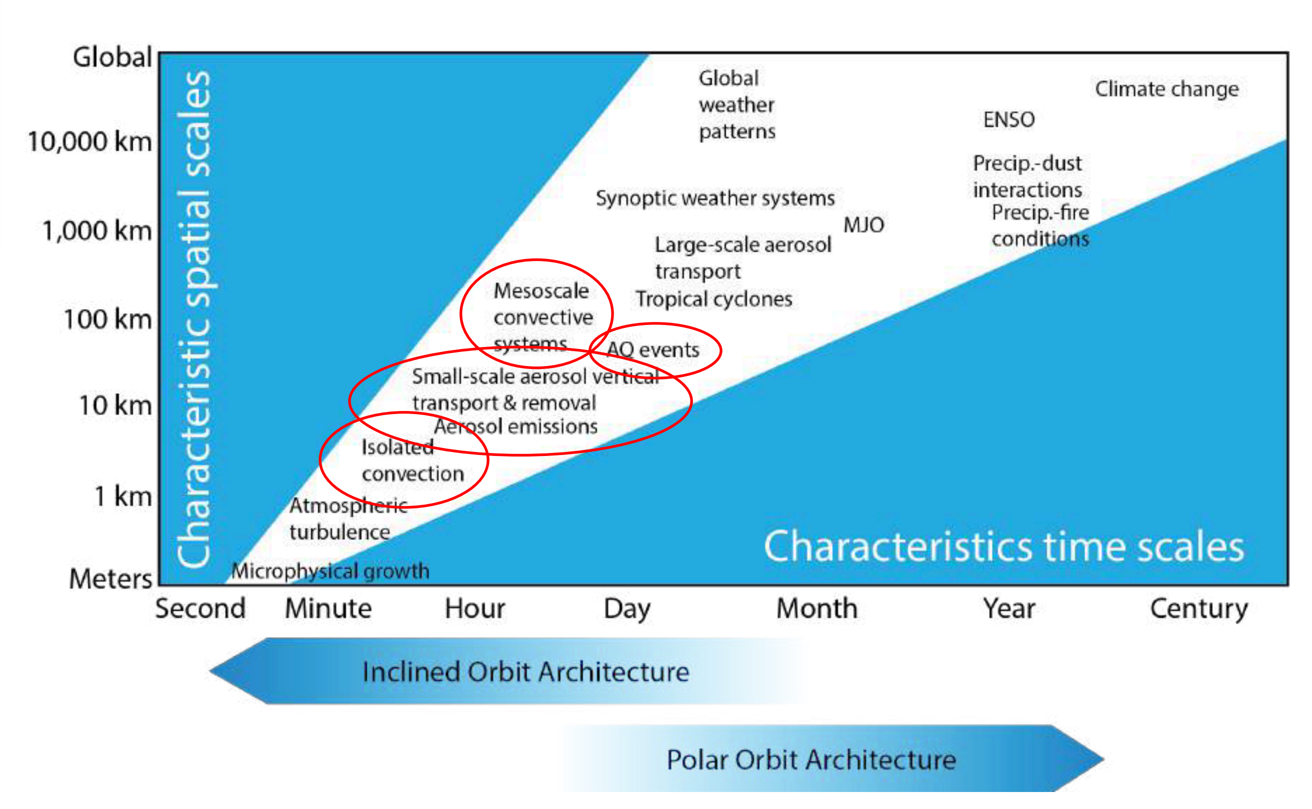
Polar Orbit: NET Dec. 2030 Launch
Inclined Orbit: NET July 2028 Launch





Sub-orbital program (aircraft & ground assets) for validation and science that cannot be done from space

AOS Science Goals & Objectives

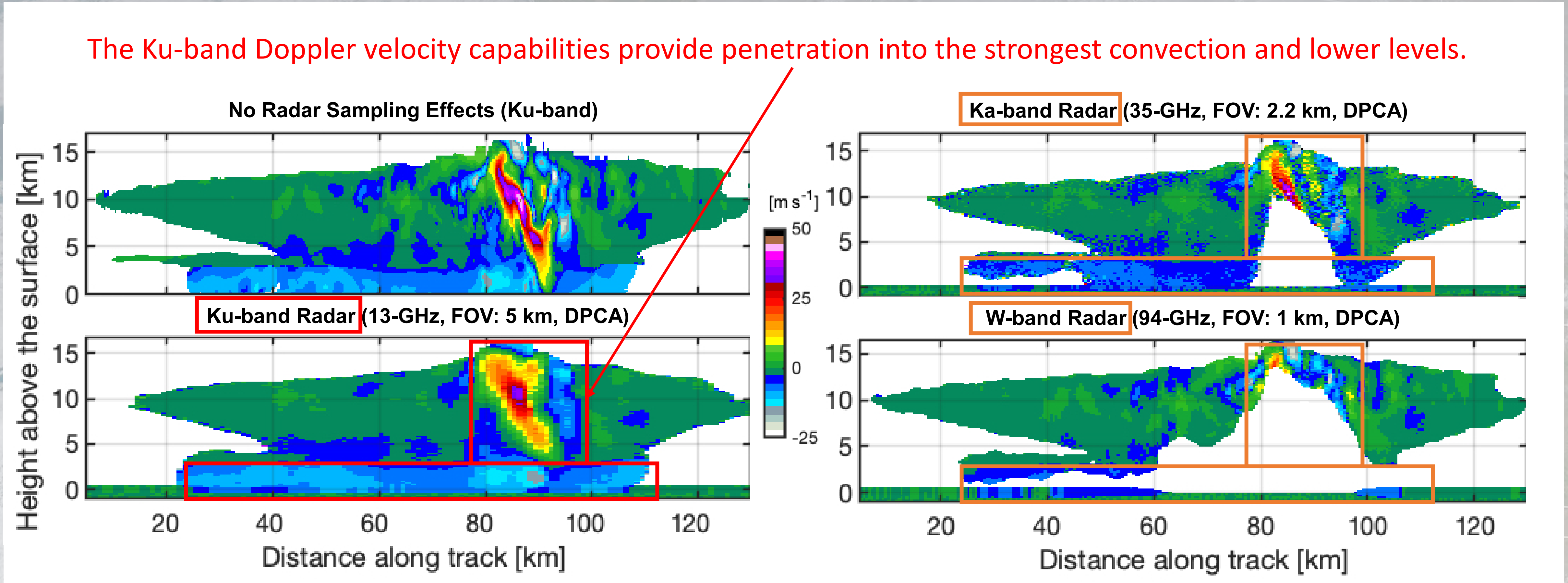
DS Questions: Climate | Convection | Aerosols

Goal	Science Objectives		Key Science Focuses	Inclined	Polar	Sub-orbital
Some aspects strongly coupled with convection and cloud processes not measured by AOS-P					√	√
G1	**O2**	**High Clouds**	Relationship of high cloud formation/properties to deep convection, large-scale environment; infrared radiative climate feedbacks	√	√	√
G2	**O3**	**Convective Storms**	Relationship between storm vertical motions and microphysics	√	√	√
Significant diurnal variability and the primary driving objective of AOS-I					√	√
G4	**O5**	**Air Quality and Aerosol Attribution**	Identifying major sources of aerosols and their type/species; factors that relate aerosol microphysical/optical properties to near-surface air quality	√	√	√
G4	**O6**	**Aerosol Redistribution and Processing**	Wet removal and processing of aerosol by clouds and precipitation; impacts of vertical and long-range transport of aerosol	√	√	√
Some aspects related to diurnal variability (O5) and vertical motion/precipitation of deep convection (O6) not measured by AOS-P					√	√
					√	√

Pre-Decisional – AOS is in Pre-Phase A and NASA makes no commitments on the final design of the mission or instruments

Vertical Motions in Strongest Convection

AOS-I furthers our understanding of convective storms because it extends the long and highly successful record of TRMM/GPM reflectivity measurements and *<u>adds highly novel and incredibly important Doppler information about vertical motion of the largest hydrometeors</u>*.



Convective Processes

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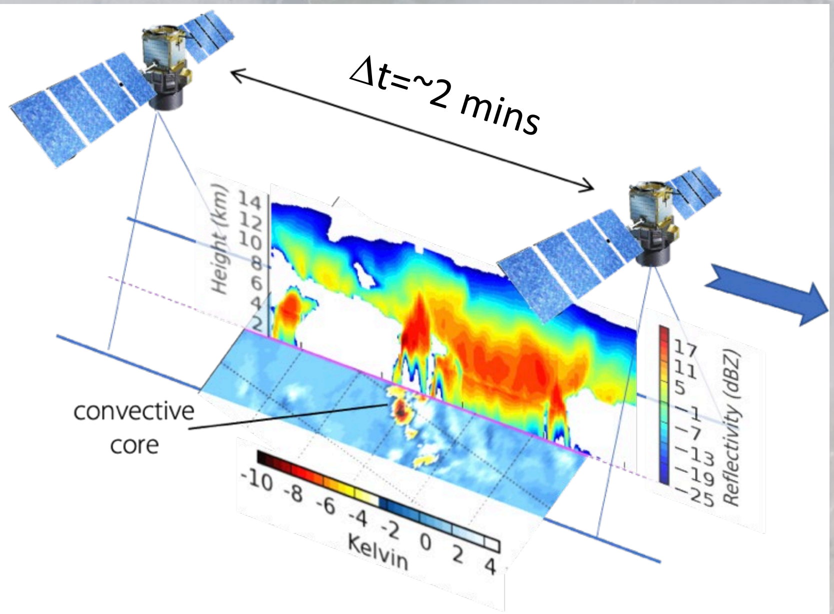
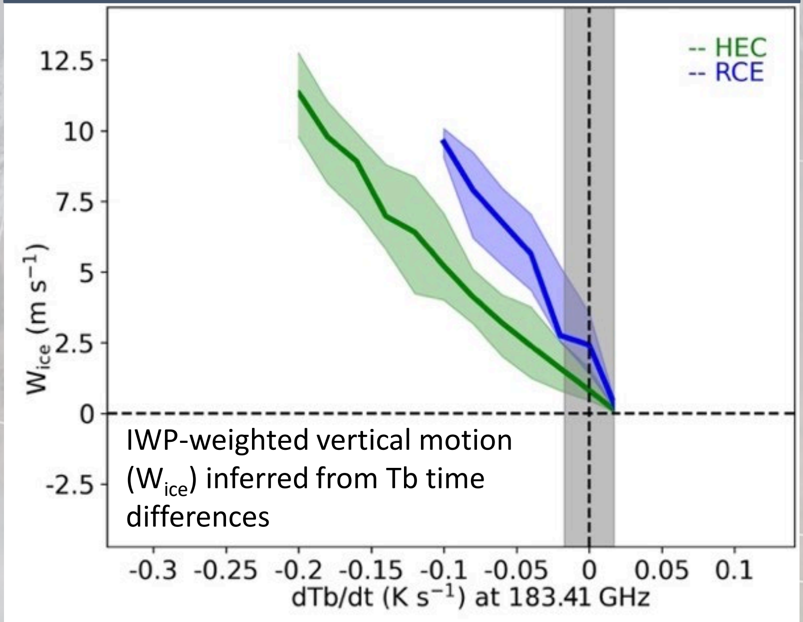
AOS-I provides the *first ever passive microwave Δt measurements* that add highly relevant information on rapid changes in the ice water path and precipitation associated with convection over a large swath.

CNES C2OMODO Mission Concept



Designed to map internal dynamics of convective systems (core + anvil)

Time-differenced radiometer measurements contain information on convective vertical motions



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Diurnal Variability of Convection

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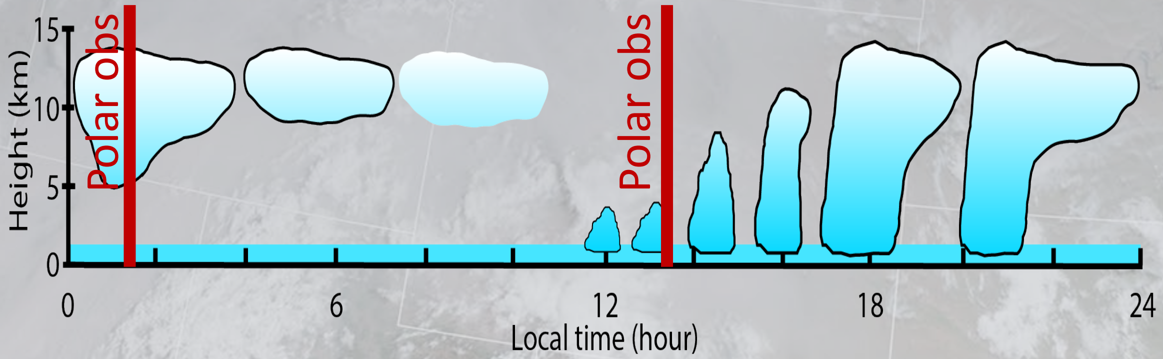
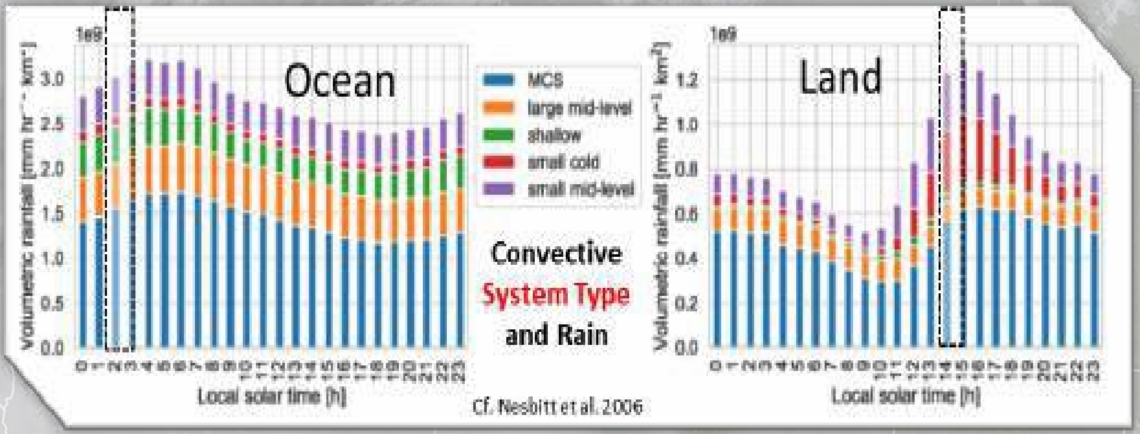
AOS-I will improve our understanding of convective dynamics and processes over the full range of the diurnal cycle, enabling more accurate predictions of rain and severe weather.

Convection and associated rainfall/vertical motions have a strong diurnal cycle, especially over land in the tropics.

While TRMM/GPM observe the diurnal variability of precipitation, convective processes are complex and not well understood, partially due to a lack of diurnally resolved measurements of vertical motion.

Diurnal cycle of convection, high clouds, and residual moisture





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High Cloud Processes & Diurnal Variability

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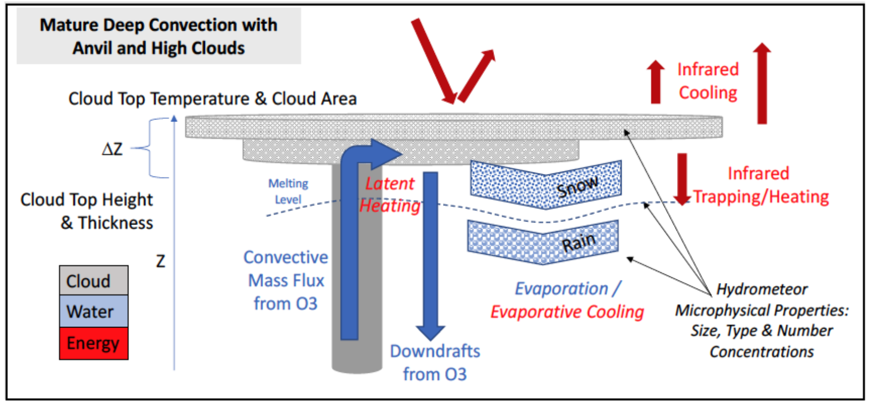
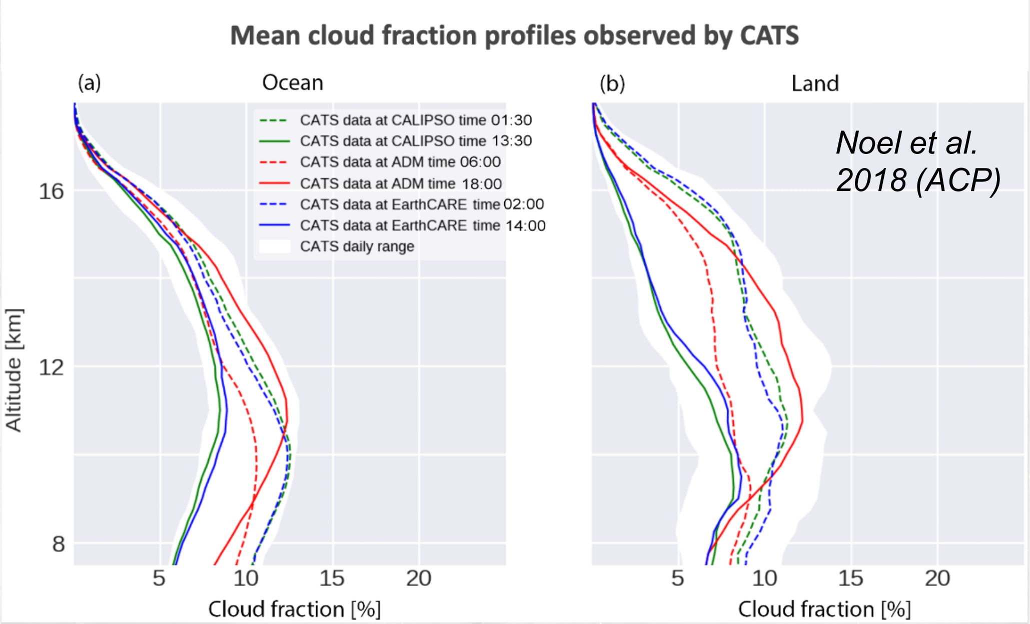
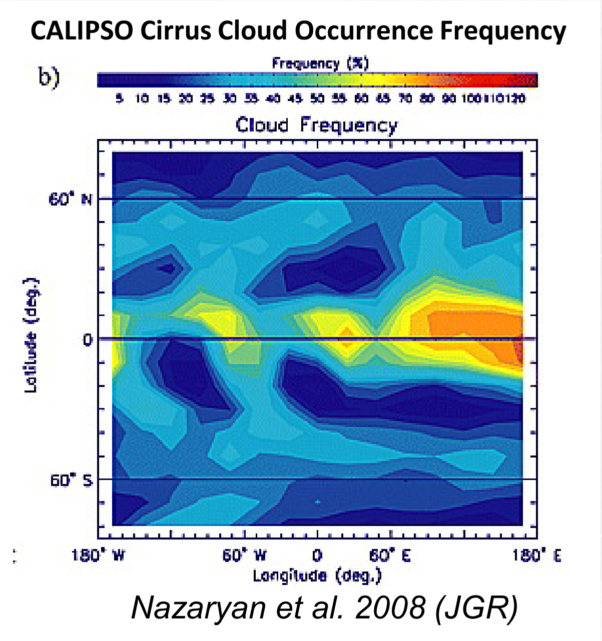
AOS-I provides *first ever collocated time-varying measurements of high clouds and convective vertical motions*, improving our understanding of processes that climate models are sensitive to but are not well constrained due to lack of global observations.



High clouds (i.e., tropical anvils) generated from convective processes also exhibit diurnal variability.



CALIPSO demonstrated an ability to detect and quantify thin high clouds, but did not sample at different times of day or have collocated measurements of convective vertical motions.



Aerosol Diurnal Variability

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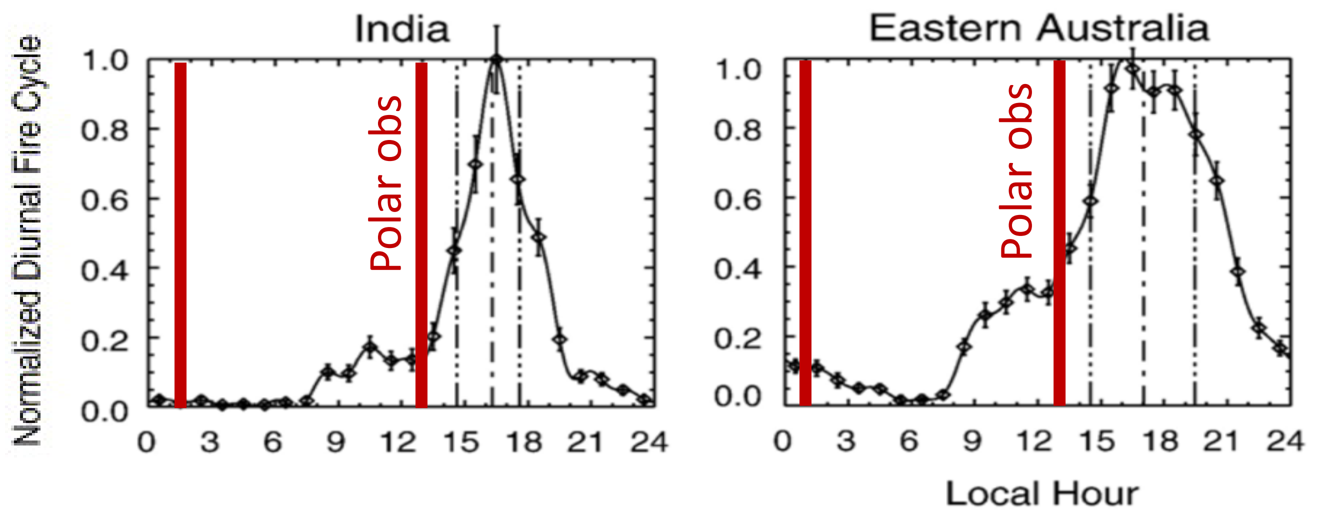
AOS-I complements AOS-P by providing vertical structure of dust (black) and smoke (red), aerosol types that a backscatter lidar best detects and quantifies (right), at different times of day not sampled by AOS-P (or CALIPSO).

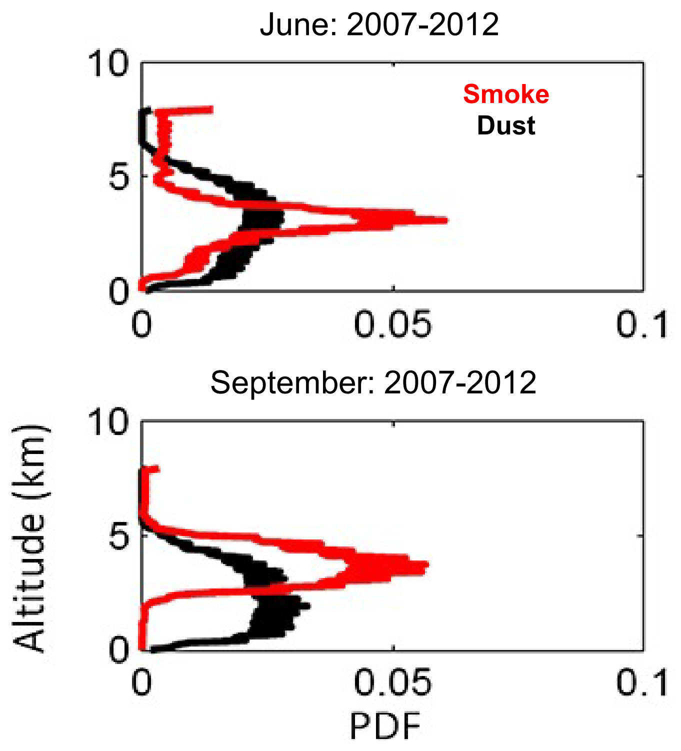
Aerosols emissions such as smoke from fires (left), dust from deserts, and black carbon from exhaust have strong vertical and diurnal variability that are critical to predicting transport and air quality.

Mean Diurnal Cycle of Fires



L. Giglio / Remote Sensing of Environment 108 (2007) 407–421

CALIPSO Dust & Smoke Vertical Distribution



Huang et al. 2016 (JGR)

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Summary

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AOS-I provides highly novel and incredibly important Doppler information about vertical motion in deep convection (largest hydrometeors) to observe convective processes on a near-global scale and enable more accurate predictions of convective rainfall and severe weather.

Synergistic radar, MW radiometer, and lidar data offer collocated time-varying measurements of convection and high clouds to statistically resolve their diurnal variability and improve our understanding of processes that are not well constrained in climate models.

The AOS-I backscatter lidar complements AOS-P by providing the diurnal and vertical variability of aerosols and aerosol mixing heights that are important to understanding and predicting air quality and aerosol processes.

The overall AOS-I project provides early science and continues important international partnerships.

The AOS-I data provide key information to support decision making that will enable improved weather and air quality forecasting, disaster monitoring and models, and water resource management.

Backup Charts

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Origin of AOS: Decadal Survey

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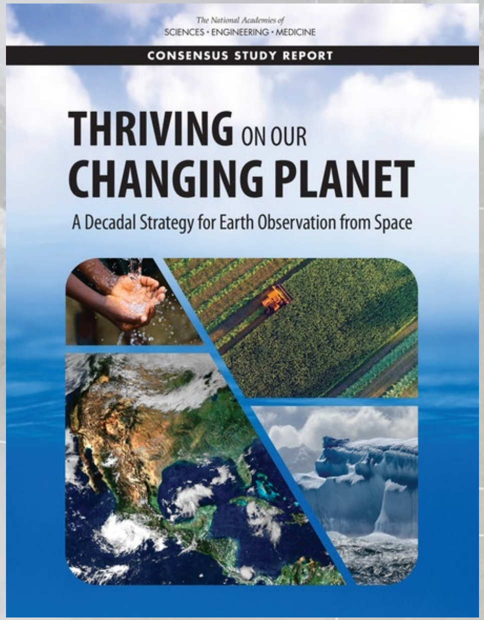
- AOS science directly flows from Decadal Survey “Most Important” Aerosol (A) and Clouds, Convection, and Precipitation (CCP) science priorities and measurement recommendations (below)
- A 2+ year multi-institutional study was performed to:
  1. Develop a project architecture by optimizing science return from mature instruments available at NASA centers or in industry
  2. Quantitatively assess architectures using simulated data and retrieval algorithms

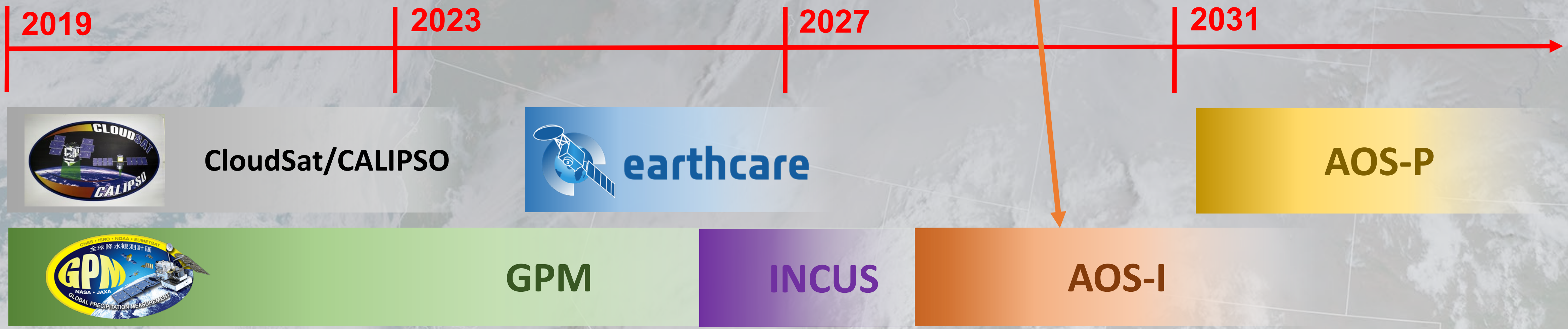
National Academies of Sciences, Engineering, and Medicine 2018

Targeted Observable	Science/Applications Summary	Candidate Measurement Approach
Aerosols	*Aerosol properties, aerosol vertical profiles, and cloud properties* to understand their effects on climate and air quality	Backscatter lidar and multichannel/multiangle/ polarization imaging radiometer flown together on the same platform
Clouds, Convection, and Precipitation	*Coupled cloud-precipitation state and dynamics* for monitoring global hydrological cycle and understanding contributing processes including cloud feedback	Dual-frequency radar, with multifrequency passive microwave and sub-mm radiometer



Early Science & International Partnerships

AOS-I provides early science that is critical given the potential gap in radar/lidar capabilities.



AOS-I continues international partnerships that made CALIPSO and GPM successful.

AOS-I Applications

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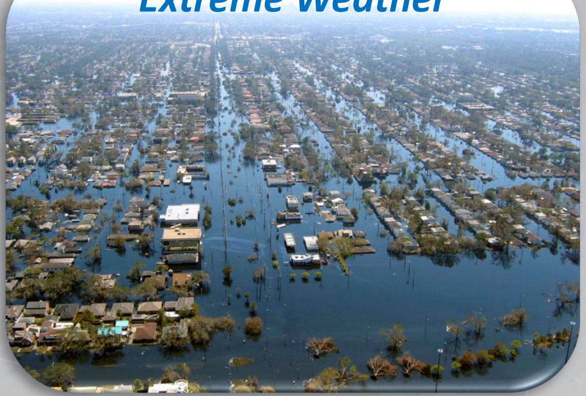
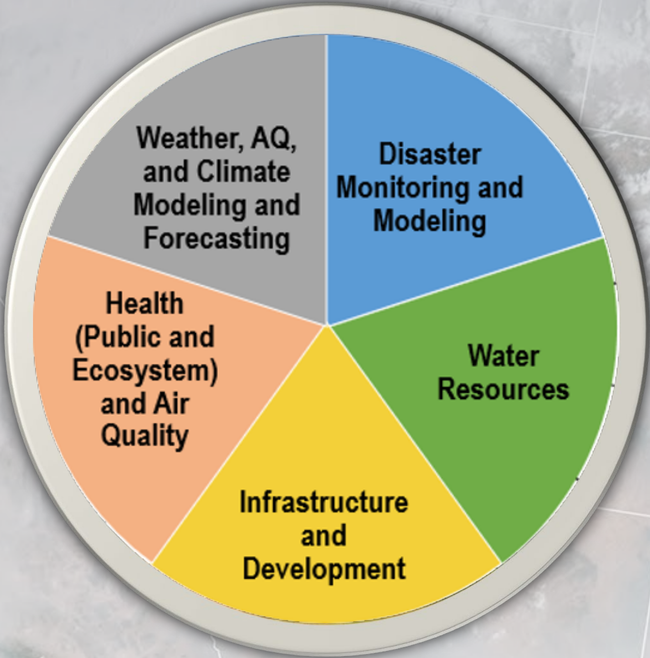
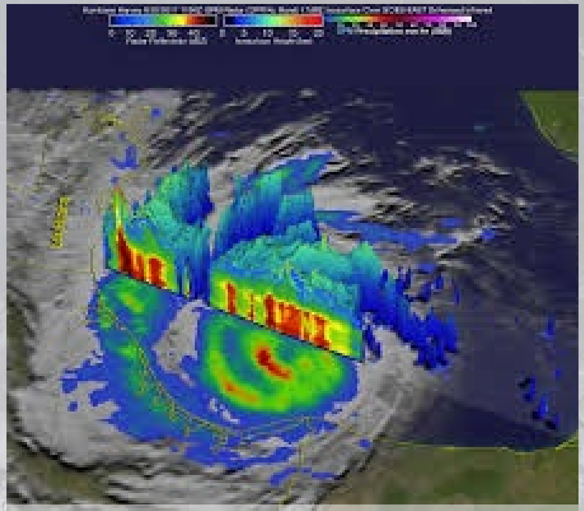
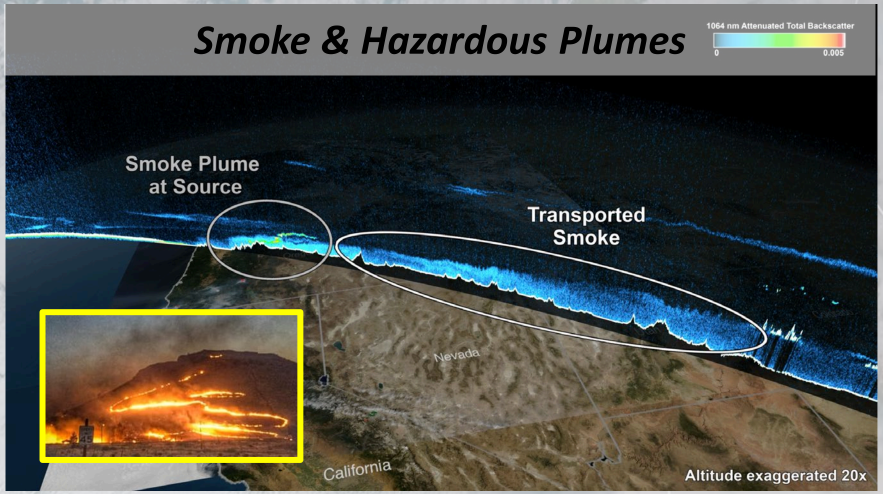

Extreme Weather

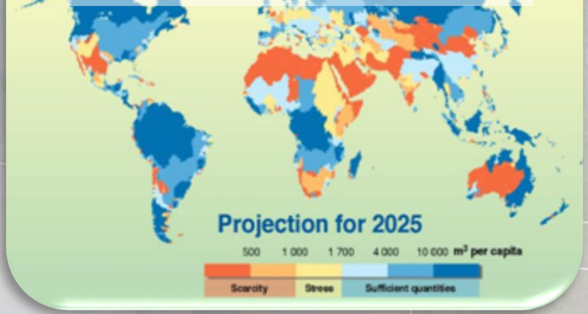



Tropical Cyclones

Smoke & Hazardous Plumes



Freshwater Availability



Achieving Science Objectives

Science Objectives (Full text in backups)	Mapping of GV to Objective	Required Geophysical Variables	Primary Enabling Measurement	Instrumentation Required
O2. *High Clouds*	O2-O3, O6	*Precipitation Rate Profile*	Radar reflectivity (Ku)	Ku-band Doppler Radar
	O2-O3, O6	*In-cloud Vertical Air Velocity*	Radar Doppler velocity (Ku)	Ku-band Doppler Radar
O3. Convective Storm	O2, O3	*Ice Water Path swath, d(IWP)/dt*	PMW Radiometer TBs	Passive Microwave Radiometer
	O2, O3, O5, O6	*Aerosol-Cloud Vertical Feature Mask*	Total attenuated backscatter	Backscatter Lidar
O5. *Air Quality and Aerosol Attribution*	O3, O5, O6	*Aerosol Extinction (VIS, NIR)*	Total attenuated backscatter	Backscatter Lidar
	O3, O5, O6	*Aerosol Depolarization Ratio (VIS, NIR)*	Total attenuated backscatter, Perpendicular attenuated backscatter	Backscatter Lidar
O6. *Aerosol Redistribution and Processing*	Additional GVs: hydrometeor vertical feature mask, cloud optical depth, precipitation phase profile, surface precipitation rate (wide swath), precipitation discrimination (e.g., stratiform, convective, anvil, other); layer-resolved (e.g., the planetary boundary layer) aerosol optical depth			